Digitizing the Battlefield

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Abstract

In 1990-91 the United States Armed Forces engaged in what many believe to have been its first information war. The many displays of technology were but a precursor to the new force known as Force XXI. Since the early 90's the U.S. Army has been right sizing and has looked for ways to make its force more lethal and survivable. This search has lead to the concept known as "Battlefield Digitization". Battlefield Digitization is an Army modernization effort taking advantage of revolutions in electronics and information technologies to make dramatic gains in all battlefield operating systems. Digitization of the battlefield means using high-speed streams of information bit-packets, moving across electronic grids, rapidly processing these packets with high resolution graphical displays and assistance from expert systems, and utilizing automated decision support systems to solve complex problems at all levels. The central piece to the digitization plan is the Army Battle Command System (ABCS). ABCS is a system of systems which include the Maneuver Control System (MCS), All Source Analysis System (ASAS), Advanced Field Artillery Tactical Data System (AFATDS), Forward Area Defense (FAD) C2I, Combat Service Support Control System (CSSCS), Global Command and Control Army (GCCS-A), Integrated System Control (ISYSCON), Integrated Meteorological System (IMETS), Digital Topographic Support System (DTSS), and Force XXI Battle Command Brigade and Below (FBCB2)/Embedded Battle Command (EBC). These systems are fed data from satellites, aerial reconnaissance, weapons systems, sensors, and ground soldiers. At the operational level the key component is the Warfighter Information Network. It is comprised of long-haul data assets and the tactical Internet. The tactical Internet is a wireless network that uses the SINCGARS and EPLRS radios combined with routers to pass information. The tactical operations center (TOC) is the central hub of this information center. At the TOC, information is received and disseminated higher and lower in the chain and forces are directed toward objectives. The battlefield systems consist of three components: C2 systems, embedded systems, and non-embedded systems. Each weapon system will be outfitted with the applique hardware, FBCB2 software, Positional/Navigation (POSNAV), SINCGARS and/or EPLRS radio, and the battlefield combat

identification system (BCIS). The individual soldier of the 21st century, known as the "Land Warrior", will be outfitted with a miniaturized computer and radio, a laser sight/range finder/video camera, a HUD, and lightweight body armor. The Army of 21st century is banking its future on technology and hopefully the promise of miniaturization and durability will reach fruition.

Introduction

In 1990-91 the United States Armed Forces engaged in what many believe to have been its first information war. Based on its' outcome and the many displays of advanced technology, such as smart bombs and stealth technology, this 100-hour battle could be viewed as an overwhelming success for U. S. Forces and point to the direction for many successes in the future. This was but a precursor of the technology that will have a tremendous impact on future wars.

At that time the Armed Forces were undergoing a reduction in manpower, with the end of the cold war, which prompted military leaders to look for new ways to increase the lethality of their shrinking forces. In 1993 the U. S. Army conducted an exercise called the Louisiana Maneuvers (LAM) to explore the impact that the information age would have on future warfare. In essence, "LAM is a laboratory to practice roles and missions, to develop and explore options, and to assess and direct progress."[1] Of the products that emerged from this exercise the most important was the concept of Force XXI. Force XXI is the army's picture and "coined-term" for the Army's 21st century land force. It envisions an army that fully utilizes the recent advancements in telecommunications to provide unprecedented situational awareness and rapid reaction to impending battles. In addition, it improves the soldier's and the equipment's ability to eliminate a target with advances in infrared, radar, and ambient light technologies. One only needs to read the quote below to realize the breadth of the changes in store.

"Force XXI will leverage the capabilities of the latest technologies to optimize the skill and courage of our soldiers. We will integrate information age technology with our tactical units. We will redesign units, built around people and new technologies, to enhance their agility, versatility and lethality."

General Gordon R. Sullivan [2]

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[1] *"Louisiana Maneuvers: The First Year,"* U.S. Army Chief of Staff, U.S. Army Publication and Printing Command, March 1994, 8.

[2] *"Army Focus 1994: Force XXI,"* U.S. Army Chief of Staff, U.S. Army Publication and Printing Command, September 1994, 9.

It must be remembered that Force XXI is the largest transition the Army has undertaken in its history and will not happen overnight. It will require many years to make the vision a reality, while at the same time the Army continues its traditional role. As such, it is a work in progress and thus most of the material contained in this report suffers from the technology bug – as soon as you get it, its outdated.

Army Operational Concepts

Joint Vision 2010 is the Armed Forces Vision. Developed by the Joint Chiefs of Staff, it contains four operational concepts that are the foundation on which the Armed Forces will be built. These operational concepts converge to form what is called "Full Spectrum Dominance."[3] From these four operational concepts the Army has added a fifth and together forms the Army Operational Concepts. The concepts, outlined below, are dominant maneuver, precision engagement, full-dimension protection, focused logistics, and information superiority.

(1) Dominant maneuver will be the multidimensional application of information, engagement, and mobility capabilities to position and employ widely dispersed joint air, land, sea, and space forces to accomplish operational tasks.[4]

(2) Precision engagement will consist of a system of systems that enables our forces to locate the objective or target, provide responsive command and control, generate the desired effect, assess our levels of success, and retain the flexibility to reengage with precision when required.[5]

(3) Full-dimension protection will be the control of the battlespace to ensure our forces can maintain freedom of action during deployment, maneuver, and engagement while providing multi-layered defenses for our forces and facilities at all levels.[6]

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[3] Edward Waltz, *Information Warfare* (Norwood: Artech House, Inc., 1998), 108.
[4] *"Joint Vision 2010,"* U.S. Joint Chiefs of Staff, U.S. Army Publication and Printing Command, 1996, 20.
[5] Ibid., 21.
[6] *"Army Vision 2010,"* U.S. Army Chief of Staff, U.S. Army Publication and Printing Command, 1996, 1.

(4) Focused logistics will be the fusion of information, logistics and transportation technologies to provide the rapid crisis response, to track and shift assets even while en route, and to deliver tailored logistics packages and sustainment directly at the strategic, operational and tactical level of operations.[7]

(5) Information superiority is the capabilities to collect, process, and disseminate an uninterrupted flow of information while exploiting or denying an adversary's ability to do the same.[8]

To ensure joint service interoperability of Command, Control, Communications, Computer and Intelligence (C4I) the Joint Chiefs of Staff (JCS) initiated the "C4I for the Warrior" concept. The Army's piece is known as the "Enterprise Strategy". Key components of the concept are Split Base/Reach Back, same look and feel of systems, and tailored C4I information or "push concept".[9] Each of these concepts will be addressed in further detail throughout this paper.

Battlefield Digitization Concept

In order to incorporate the advancements in computers and communications with the Army operational concepts the Army has instituted what it calls "Battlefield Digitization". "Battlefield Digitization is an Army modernization effort taking advantage of revolutions in electronics and information technologies to make dramatic gains in all battlefield operating systems and at every level, from crews and squads up to the National Command Authority. Digitization of the battlefield means using high-speed streams of information bit-packets, moving across electronic grids, rapidly processing these packets with high resolution graphical displays and assistance from expert systems, and utilizing automated decision support systems to solve complex problems at all levels."[10]

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[7] Joint Vision, 24.
[8] Army Vision, 23.
[9] *"Army Digitization Smart Book,"* Army Digitization Office, September 1996, 24.
[10] Louisiana Maneuvers, 23.

Digitization provides the deciders, shooters, and supporters timely and relevant data that will allow them to overwhelm and overcome the enemy. It replaces the slow voice and liaison communications with high-speed voice and data communications via a network. This robust network, horizontal and vertical, provides a common picture (Figure 1) at all echelons simultaneously through a collection of sensors, command posts, processors, and weapons platforms.[11] While network(s) provide situational awareness to the deciders and shooters, the supporters of Force XXI use them to sustain the deployed force. Force XXI will only deploy with limited supplies and the majority of the sustaining base will remain stateside. This concept is known as Split Based Operations. The Standard Army Retail Supply System will operate on a fixed computer in the continental US, and deployed forces will submit requests via electronic data interchange through a laptop or workstation.[12] In order to be responsive the Army will incorporate total asset visibility (TAV). "TAV enables the Army to track continuously the flow of equipment and supplies, in production or at a repair depot, in inventory somewhere in the DOD supply system (including items that are in the hands of end users), and most importantly, on the move between various locations."[13] This concept is similar to the system employed by UPS and FedEx, which makes extensive use bar coding and database technologies.

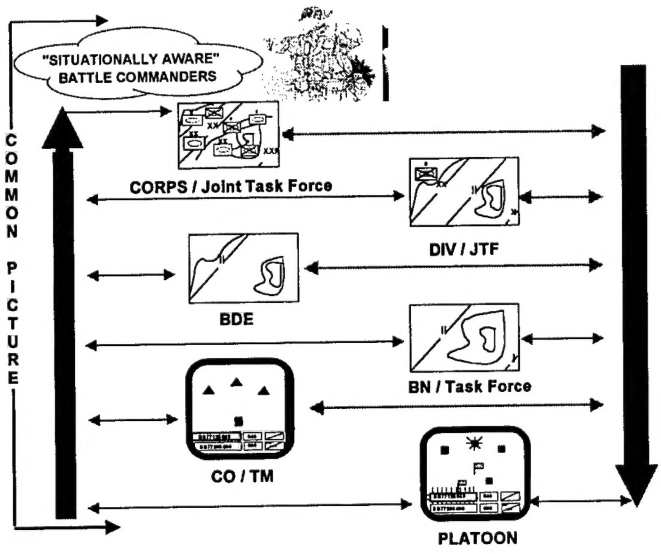

Figure 1 – Common Picture

[11] *"Army Digitization Master Plan,"* Army Digitization Office, March 1, 1996, 1-5.
[12] Army Focus, 21.
[13] Ibid.

Army Battle Command System (ABCS)

Army Battle Command System (ABCS) is the central piece of the digitization plan. It is not a single system, as its name might imply, but a complex system of systems that link automation assets, communication media, and operational facilities. ABCS provides commanders the ability to collect and analyze information, develop plans and orders, and monitor the tactical battlefield while simultaneously planning for future operations.[14] It also contains the vital link between the Army Command and Control System (GCCS-A) and the Armed Forces Command and Control System (GCSS), which provides the ability to receive and transmit information among joint forces. The subsystems of ABCS are outlined in the Table 1.[15]

The essential subsystem of ABCS is the Army Global Command and Control System (GCCS-A). It provides the direct link between the Army and other joint services as well as allied coalition partners. As such it provides the capability to mobilize, deploy, and support Force XXI anywhere in the world. It provides accurate, timely, and synthesized information for decision-making to both strategic and tactical commanders. GCCS-A uses the Common Operating Environment (COE) and as such supports system expansion consistent with an open systems environment, and can interface with existing C2 systems via software updates.[16]

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[14] Steven Boutelle and Charles Pizzutelli, "Army Battle Command System," *Army Research, Development, and Acquisition Magazine* PB 70-98-5, September-October 1998, 8.
[15] Boutelle, 9.
[16] Army Focus, 19.

ABCS Subsystem	Function
Maneuver Control System (MCS)	Plans, coordinates, and controls current operations, and develops and distributes plans, orders, and estimates in support of future operations
All Source Analysis System (ASAS)	Develops and provides the picture of enemy situation to commanders at all echelons; Accesses information from national, theater, and tactical sources
Advanced Field Artillery Tactical Data System (AFATDS)	Provides automated support for the planning, coordination, control, and execution of close support, and deep fires from Army and Joint (Naval gunfire, close air support) assets
Forward Area Air Defense (FAAD) Command, Control and Intelligence	Integrates air defense fire units, sensors, and command and control centers into system for defeating low-altitude threat and enables commanders to plan, coordinate, direct, and control the counter air fight
Combat Service Support Control System (CSSCS)	An automated system for logistical, medical, financial and personnel support; Provides critical combat service support information to assist decision-making and battle planning process
Global Command and Control System Army (GCCS-A)	Provides access to the Global Command and Control System; Disseminates common operational picture data between the Army and other Services; The Army's strategic and theater command and control system
Integrated System Control (ISYSCON)	Performs network planning and management of the communications architecture EAC to brigade; For brigade and below Automatic Network Managers (ANM) are used based on the Simple Network Management Protocol (SNMP)
Integrated Meteorological System (IMETS)	Provides weather information based on inputs from Air Weather Service and meteorological sensors
Digital Topographic Support System (DTSS)	Produces topographic products, to include multiple full-color maps of the battlefield and custom maps in digital format
Force XXI Battle Command Brigade and Below (FBCB2)/Embedded Battle Command (EBC)	Develops and provides situational awareness and relevant battle command information of friendly troops at brigade and lower echelons; Disseminates situational awareness information to brigade and lower echelons

Table 1 – ABCS Subsystems

Information Sources

With all these system and subsystems pushing, pulling, and storing data the next question to answer is, where is the data coming from. There are a multitude of sources ranging from the individual soldier and sensors on the ground to the aerial and satellite assets above. Figure 2 displays a sampling of the data collection sources available to the information warrior of the future.[17]

[17] Army Digitization Smart Book, 7.

Two observations can be made from this figure. First, that there are literally thousands of data collection assets and second, that most of these assets will need to communicate via radiated media (satellite, cellular, radio, etc.). The central data collection point is the All Source Analysis System (ASAS). ASAS is a ground-based, mobile, automated intelligence processing and dissemination system designed to provide timely and accurate intelligence and targeting support to the battle commander.[18] In addition, it provides communications and intelligence processing capabilities to allow sensor and other intelligence data to automatically enter into the all-source database and be simultaneously available at multiple analyst workstations.[19] In other words, ASAS automates the retrieval, processing, and dissemination of data without user intervention.

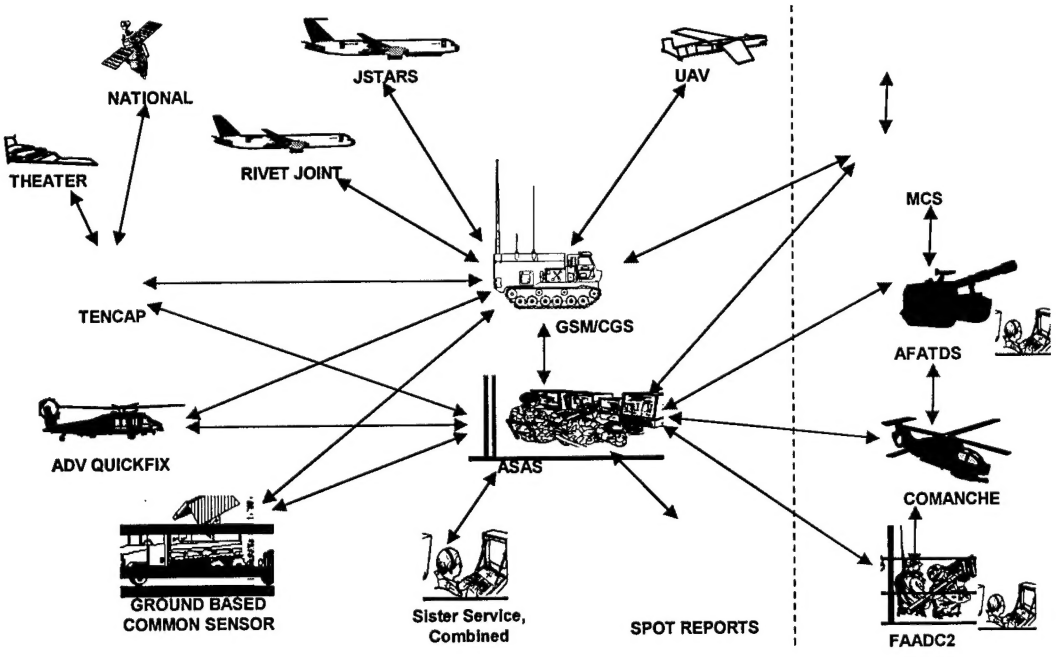

Figure 2 – Information Sources

Due to the mobile nature of warfare and the rapidly depleting availability of spectrum, the Army will

[18] Army Digitization Master Plan, 5-6.
[19] Army Digitization Master Plan, 5-6.

rely heavily on satellite communications. Military satellite communications (MILSATCOM) projects consist of the extremely high-frequency (EHF) military strategic tactical relay (MILSTAR) satellite program, and the ultra-high frequency (UHF), super-high frequency (SHF), and commercial C- and Ku-band tactical satellite programs. MILSTAR provides two-way, anti-jam, low probability of intercept, secure voice and data communications.[20] The tactical satellite programs provide the reach-back capability between a deployed force and its sustaining base in the US. In order to fully use the satellite resources the Army is developing what is call the Global Broadcast Service (GBS)/Battlefield Awareness and Data Dissemination (BADD) architecture. "In the GBS/BADD architecture, Figure 3, the information dissemination server (IDS) collects and evaluates information available in databases from national and theater sources and disseminates this information to the deployed soldier within a tactical theater of operations. When the information available matches a soldier's need posted via the reach-back link, the IDS sends the information via the return link to a GBS uplink earth station for transmission to a satellite. The satellite broadcasts the information to the soldier's downlink GBS receiver at a remote site. At the receiving station, the broadcast data are deposited into a workstation local to the soldier referred to as a warfighter associate (WFA). The WFA, among other functions, replicates the databases from which information was drawn and functions as a local server. The data is then available to other user workstations via Tactical Operations Center (TOC) local area

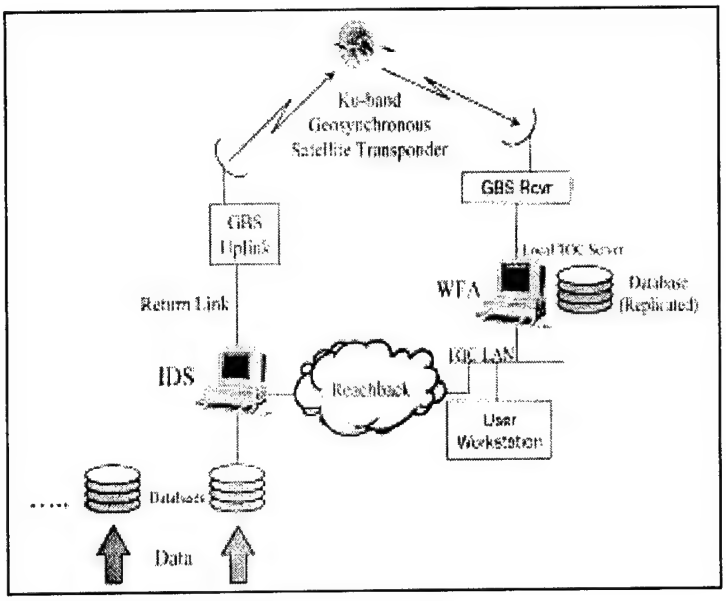

Figure 3 – GBS/BADD

[20] "Army Weapons and Equipment," *Army Magazine 1999-2000 Green Book* Vol. 49, No. 10, October 1999, 289.

networks (LANs)."[21] Types of information disseminated include data, imagery, maps, intelligence overlays, real-time video, weather, and logistics status.

Warfighter Information Network

The essence of this information network is based on what is called the Warfighter Information Network (WIN). The two major components of WIN are the tactical Internet (TI) and the WIN-Terrestrial (WIN-T). TI is used at the brigade and below, and at mobile entities at higher headquarters that use the Single Channel Ground Airborne Radio System (SINCGARS) or the Enhanced Position Location Radio System (EPLRS) for data exchange. WIN-T provides long-haul capabilities at division and higher headquarters.

The WIN system works similar to the Internet and shares many of the same standards (e.g. Host Standards: FTP, TCP/IP, Border Gateway Protocol (BGP) & Network Standards: PPP, Ethernet X.25 and MIL-STD 188-220A (a suite of protocols used with Combat Net Radio (CNR) systems, such as SINCGARS).[22] The operator simply enters the destination(s) for traffic and transmits it without having to switch frequencies or worry about the type of transmitter. Similar to the commercial Internet, the WIN infrastructure will resolve these issues and swiftly transmit the information to its proper destination.[23]

The Tactical Internet covers communications infrastructure at Corps and below and provides gateways to strategic levels. The tactical Internet provides seamless communications connectivity for ABCS subsystems, embedded and non-embedded systems (e.g. applique). The TI is based on commercial standards and protocols that use a common operating environment and will provide for joint and combined interoperability. This is achieved through the employment of commercial Internet technology (e.g. IP routers) and open standards protocols (e.g. TCP/IP). Commercial-off-the-Shelf (COTS) IP-based routers (e.g., Tactical Multinet Gateways (TMG) and Local Area Networks (LAN) routers) and Internet

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[21] Ameet R. Bhatt and Michael P. Orr, "Battlefield Awareness and Data Dissemination," *Army Research, Development and Acquisition Magazine* PB 70-98-5, September-October 1998, 41-42.
[22] Army Digitization Master Plan, 4-11.
[23] Boutelle, 8-9.

Controllers (INC) provide the ability to send messages between any segment of the tactical battlespace network.[24]

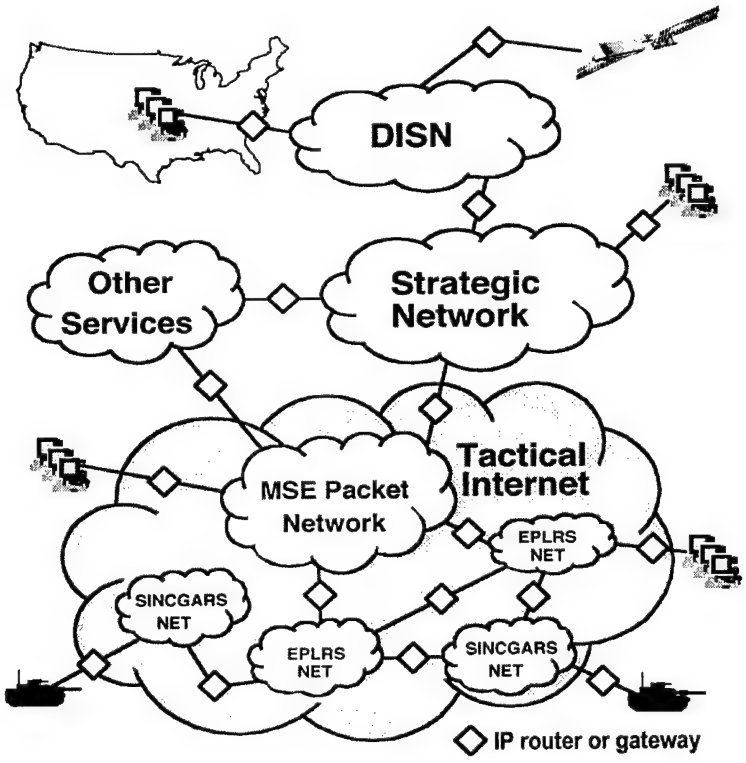

Figure 4 – Tactical Internet

The tactical Internet, Figure 4, consists of a Multiple Subscriber Equipment (MSE) Tactical Packet Network with SINCGARS System Improvement Program (SIP) and EPLRS Very High Speed Integrated Chip (VHSIC) radios integrated via routers. MSE provides a secure tactical communications system capable of passing data, facsimile, and voice traffic throughout the division and corps area of operations. Future enhancements for long-haul capabilities include a High Capacity Line of Sight radio (to replace MSE Line of Sight radio) and Asynchronous Transfer Mode (ATM). These new technologies will increase the transmission range and efficiency of bandwidth by use of ATM dynamic allocation methods.[25] SINCGARS is a reliable and secure, combat net radio (CNR) that has voice and data handling capability with a data transfer rate of 4.8 kbps and range of 35km. SINCGARS, combined with and Internet controller card, provides the communications link for Task Force XXI.[26] EPLRS provides data distribution and position/navigation services in near-real time at brigade and below in support of battlefield functional area (BFA) hosts and the force battlefield command and brigade and below (FBCB2) subsystem. EPLRS consists of a network control station (NCS) and EPLRS user units

[24] Army Digitization Master Plan, 6-5.
[25] Army Weapons, 291.
[26] Army Weapons, 293-294.

(EPUUs) that can be configured as a man-pack unit (MPU), a surface vehicle unit (SVU) and an airborne vehicle unit (AVU). EPLRS uses time-division multiple-access (TDMA) to avoid transmission contention and frequency hopping, error detection and correction with interleaving, and spread-spectrum technology to provide jamming resistance.[27] EPLRS w/VHSIC can provide data rates up to 12 kbps. Since it is strictly a data communications device it must be used in conjunction with SINCGARS to provide voice communications. Satellite communication systems provide an extension of the TI to support spilt-based operations and connectivity to national sources.[28] To insure interoperability a variable message format (VMF) has been devised and approved. There are 51 standard message types.[29] A key future enhancement to the TI is the Surrogate Digital Radios (SDR). SDR will provide for increased "data hauling" capacity between tactical operation centers (TOCs). This combination of radios represents a short-term fix for the growing bandwidth needs of the TI. The long-term solution to meet both the growing bandwidth need and provide commonality between services is the Joint Tactical Radio System (JTRS).

The Joint Tactical Radio System Program was established in 1997 to eliminate radio system redundancy and ensure communications compatibility among all services. Currently there are between 25 and 30 families of radios between all the services.[30] Most radio systems cannot communicate freely between one another because they were developed as stovepipe systems, with no thought given to the compatibility of their architectures. The JTRS family will replace these legacy systems over time in each of the services. JTRS are high-capacity tactical radios that will provide both line-of sight and beyond-line-of-sight Command, Control, Communications, Computers & Intelligence (C4I) capabilities. JTRS will support multiple bands and modes, will be software-programmable and operate in the bandwidth spectrum from 2 to 200 MHz.[31] It will be capable of transmitting voice, video and data. JTRS will

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[27] Army Weapons, 295.
[28] Army Digitization Master Plan, 6-5.
[29] Army Digitization Smart Book, 33.
[30] COL Wells Barlow and LTC Edward Poore, "Joint Tactical Radio System Program," *Army Research, Development and Acquisition Magazine* PB 70-98-5, September-October 1998, 16.
[31] Barlow, 15.

operate in three domains: airborne, ground forces (handheld, dismounted, vehicular), and maritime/fixed station. This means that there will be several types of JTRS but they will all be based on the same open architecture and thus able to communicate with one another. The success of the JTRS program is critical to Force XXI and the Armed Forces ability to communication across services and with coalition forces.

Tactical Operations Center (TOC)

Tactical operations centers are command and control centers used at all levels of command. At the TOC, military leaders plan and control operations of their units. Control is maintained through a complex communications system that utilizes both commercial LAN/WAN technology and communication protocols.

For echelons brigade and above, the primary interconnecting wide area network (WAN) is comprised of an Internet protocol network over an asynchronous transfer mode (ATM) backbone. Hosts at the division and brigade are grouped in tactical operations centers. Figure 5 shows a typical brigade level TOC and its interconnection to the WAN via a small extension node (SEN).[32] "For intra-TOC communications, a local area network (LAN) is used. A Near Term Digital Radio (NTDR) provides WAN connectivity to the battalion level as well as backup capabilities for brigade and above. Finally, the SINCGARS and EPLRS provide connectivity to the Force XXI Battle Command Brigade and below (FBCB2) situational awareness networks also known as the tactical Internet."[33] For security, firewalls and intrusion detection devices (IDS) are used. The firewalls screen transmissions in and out of the TOC to ensure only authorized users and information is being passed. IDS ensures any malicious attempts to hack or destroy information are detected in time for the operator to conduct counter-measures. Future security enhancements include stronger identification and authentication, possibly the use of biometrics, and the development of the Public Key Infrastructure (PKI).

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[32] Robert R. Lehnes and John Skrletts, "Protecting the Digitized Force," *Army Research, Development and Acquisition Magazine* PB 70-99-5, September-October 1999, 11.
[33] Lehnes, 11.

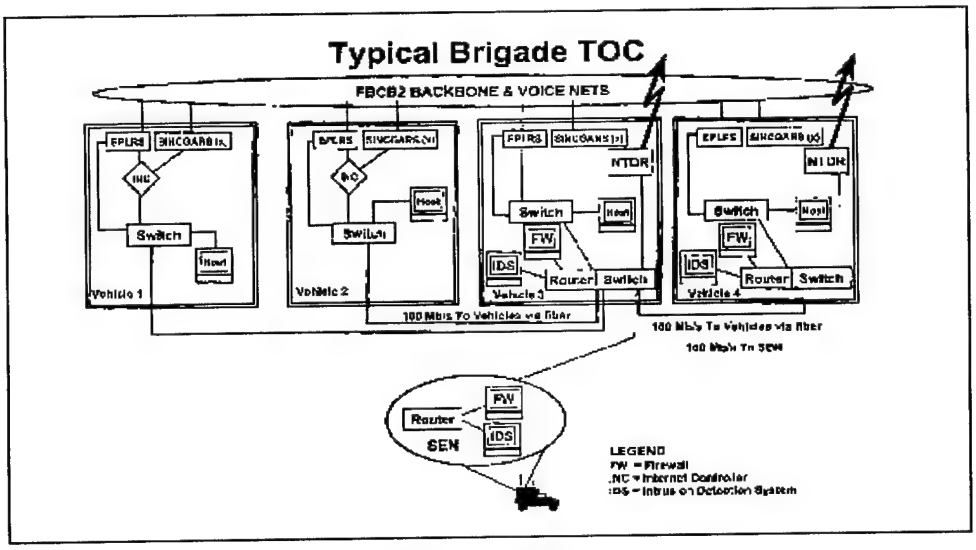

Figure 5 – Brigade TOC

Figure 6 shows a typical battalion-level TOC and its connectivity.[34] For inter-TOC communications the primary WAN connection is provide by the NTDR. For intra-TOC communications, a wireless LAN is used to accommodate the higher mobility requirement for this level of operations. As in the brigade TOC, the SINCGARS and EPLRS provide connectivity to the FBCB2 tactical Internet. In addition, security is provided by the use of firewalls and IDS.

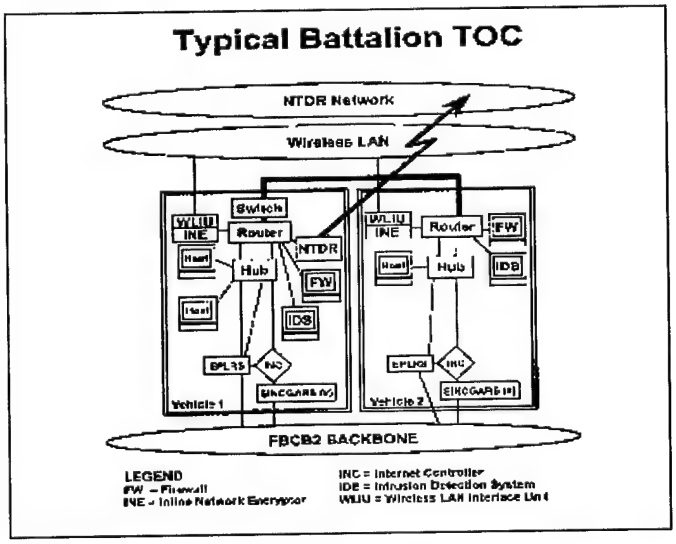

Figure 6 – Battalion TOC

[34] Lehnes, 12.

Battlefield Systems

Battlefield systems consist of three components, C2 systems (ABCS subsystems), embedded systems (currently installed in equipment), and non-embedded systems (soldiers and legacy equipment). In order to ensure interoperability between all entities a common software package was developed. Figure 7 shows how the common software provides an interface between a soldier or weapon system and its platform specific software and the tactical Internet. For non-embedded systems or deficient legacy systems, the system will be outfitted with the applique hardware, FBCB2 software, Positional/Navigation (POSNAV), SINCGARS and/or EPLRS radio, and the battlefield combat identification system (BCIS).[35]

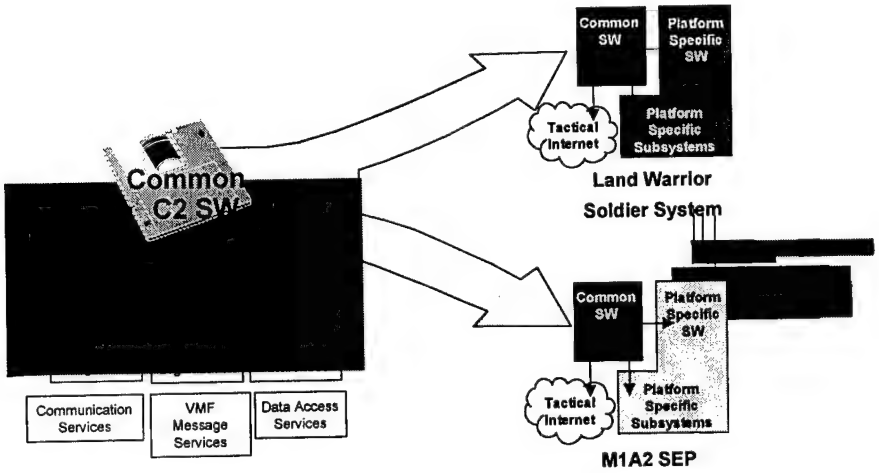

Figure 7 – Common Software

The key embedded component is the applique. The applique is a specialized laptop computer that allows a soldier or crews the ability to see the battlefield in near real time. It interfaces with a wireless Intranet that is provided data (satellite, aerial, and human intelligence) via radios or receivers mounted on vehicles. "The applique crunches the data and produces a picture of the battlefield that appears on the monitors of the computers in the field. With pinpoint precision applique can relay the position of the enemy units and vehicles so that a tank commander can see where the enemy is long before his enemy

[35] Army Digitization Smart Book, 45.

sees him."[36] It also maintains the exact locations of enemy and friendly forces with the use of global positioning system (GPS) transceivers and logistics dispositions.

The use of appliques is intended to provide command and control (C2) capabilities to platforms that either have no embedded C2 capability or whose existing capability in terms of processing power, and displays are inadequate to meet emerging user requirements. For a platform that has no digital equipment, the applique will consist of a GPS receiver, a computer unit (commercial, ruggedized or militarized), displays and interface units.[37]

In the following paragraphs are examples of how these battlefield systems are incorporated into the M1A2 Abrams Tank (a representative weapon system) and the Land Warrior (a soldier system).

M1A2 Tank Weapon System

The M1A2 Abrams Tank is the deadliest tank and possibly the most lethal weapon in the world. Unlike its predecessors, it is more a computer than a weapon. Nearly every control and weapon system relies on an embedded computer for its operation. Shown in Figure 8, is the M1A2 weapons system architecture, which is composed of a system of sensors.[38] These sensors are composed of six subsystems, Turret Processor, Commander's Display and Processor, Hull Processor, Fire Control Processor, Driver's Display, and Gunner's Display, that are interconnected by a 1553 data bus. The layout of the systems is similar to that employed in the bus architecture of a LAN. The sensors act as both a receiver and sender of data to the tactical Internet. Thus, it serves two roles, one as a shooter (primary role) and one as a sensor (secondary role). Digitization of the tank frees the crew from most of the mundane tasks and

[36] James Adams, The Next World War: Computers Are the Weapons & the Front Line is Everywhere (New York: Simon & Schuster, 1998), 112.
[37] Army Digitization Smart Book, 28.
[38] LTC George Patten and MAJ Craig Langhauser, "The World's First 21st Century Tank," *Army Research, Development and Acquisition Magazine* PB 70-97-2, March-April 1997, 18.

improves their driving, navigation, target identification, and the passage of information between members of the crew, other tanks and C2 nodes.[39]

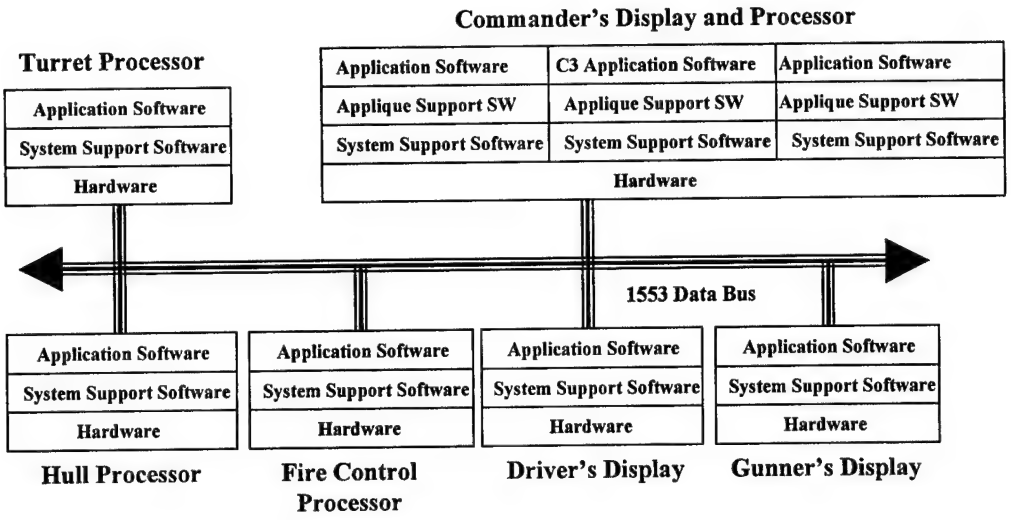

Figure 8 - M1A2 Weapons System Architecture "System of Sensors"

Figure 9 shows the non-embedded systems that will be added to the M1A2 Abrams Tank.[40]

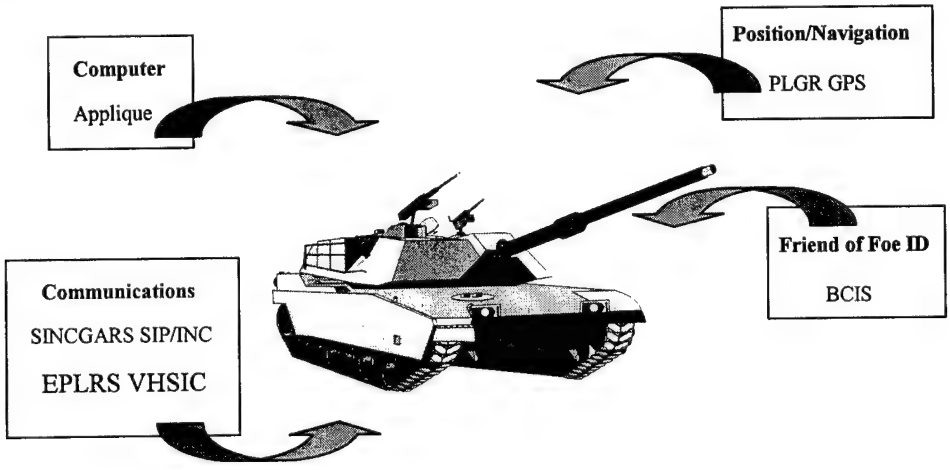

Figure 9 - M1AI w/ new systems

[39] LTC George Patten and Jimmy W. Whiteley, "The World's First Information Age Ground Combat Weapon System," *Army Research, Development and Acquisition Magazine* PB 70-96-5, September-October 1996, 23.
[40] COL Steven A. Emison, "Post Task Force XXI Advanced Warfighting Experiment," *Army Research, Development and Acquisition Magazine* PB 70-97-5, September-October 1997, 5.

Land Warrior

Now that we have addressed the C2 systems and the weapons systems the next area of interest is the individual soldier of the 21st century. Specifically, we will look at what the soldier carries and how he/she will connect to these other systems. The integration of flesh and machine is called the "Land Warrior". The heart of Land Warrior (Figure 10) is a slim-line computer and radio shaped to fit the soldier's pack frame. The radio is wired to the computer, which is connected to a laser sight/range finder/video camera on a modified M4 carbine and to an audiovisual display in the helmet. The system acts as a secondary visual system and can send signals via radio directly to the command post. The cables of the system are integrated in the pack as well as a GPS transceiver. "This data, combined with input from the gun-mounted laser range finder (effective to 1.5 miles), is fed into the computer, which calculates precisely the coordinates of an enemy position. The radio then sends those coordinates back to the base along with a still video image."[41] Currently real-time video images are not possible due to bandwidth restrictions. The Land Warrior is protected by lightweight body armor and helmet sensors can detect incoming laser threats and set off alarms in the heads-up display (HUD). The soldier is also equipped with night vision capability. The system runs on both rechargeable and/or disposable batteries.

Figure 10 – Land Warrior

Future enhancements include the "intelligent uniform", which will consist of embedded computer, communications, and power management electronic systems. It is made of polyester woven with fiber-optic wires that act as sensors and is airtight and climate controlled to protect the soldier from the environment and chemical and biological contamination.[42] The Land Warrior's future helmet will protect the soldier against ballistic, acoustic, and energy threats and attaches to the battle dress uniform (BDU) forming an airtight

[41] Adams, 109.
[42] Adams, 110.

seal.[43] In addition, the HUD will display tactical, positional, and situational data, mapping icons and a variety of additional essential data. The helmet will also include an integrated GPS antenna.[44] To enhance the soldier's strength and endurance, a system of body augmenting memory-fabric or mechanical assist muscles will be incorporated into the uniform.[45] An advanced physiological monitoring system will analyze and provide medical data to the unit commander and medical personnel. "Further protections will be afforded by a metamorphic or chameleonic camouflage capability to mask the soldier's visual and infrared signatures and an integrated, 360-degree combat identification system to enhance friend or foe identification and reduce fratricide."[46] The individual weapon of the future will perform multiple roles to include assault rifle, sniper rifle or light anti-armor weapon. An advanced set of sensors will allow targets to be engaged in excess of 1,000 meters and system software will compute firing solutions to identify and prioritize multiple targets. Maybe the storm troopers of the Empire in "Star Wars" aren't so far fetched. Let's just hope the exoskeleton we use can stop a bullet, a laser or a light-saber.

Network Centric Warfare

Warfare in the information age will see dramatic changes in lethality, and survivability. Information age warfare is known as Network Centric Warfare (NCW) (Figure 11). Network Centric Warfare is defined as, "an approach to the conduct of warfare that derives its power from effective linking or networking of the warfighting enterprise. It is characterized by the ability of geographically dispersed forces to create a high level of shared battlespace awareness that can be exploited via self-synchronization and other network-centric operations to achieve the commander's intent."[47] Several key concepts are contained in the definition above. The first key concept is the use of geographically dispersed forces.

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[43] LTC Philip J. Carey, The March Toward the Future Warrior," *Army Research, Development and Acquisition Magazine* PB 70-99-4, July-August 1999, 8.
[44] Carey, 8.
[45] Carey, 8.
[46] Carey, 9.
[47] David S. Alberts, John J. Garstka and Frederick P. Stein, "*Network Centric Warfare: Developing and Leveraging Information Superiority*, " CCRP Publication Series, May 1999, 88.

In the past, the principle of mass was based on the concentration of military forces to provide maximum firepower. In the future, as sensors and weapon ranges increase they will no longer need to unite to reach maximum effectiveness. They will simple identify the target as an enemy and mass the firepower on the threat. This in turn will reduce our battlespace footprint and cost, as assets will not have been transported and soldiers can remain out of harms way.[48] The second key concept is that our force is knowledgeable. Because they have a common picture of the situation and the commander's intent, the forces of the future will be able to self-synchronize, operate in a smaller footprint, and be more effective operating autonomously[49]. The last key concept is that there is effective linking achieved among entities throughout the battlespace. What this means is that a high performance information structure, such as ABCS or future editions, allows dispersed entities to generate synergy and that responsibilities can be dynamically reallocated to adapt to the situation.[50]

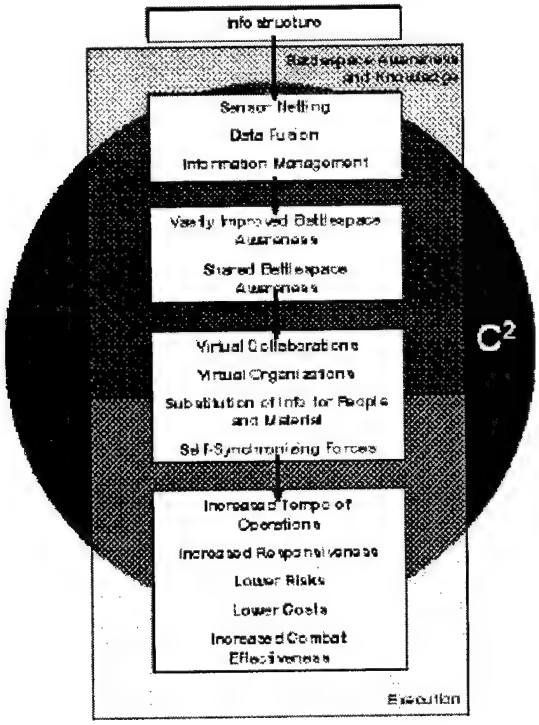

Figure 11 – The Military as a Network –Centric Enterprise

[48] Alberts, 89.
[49] Alberts, 90.
[50] Ibid.

Network Centric Warfare will also have a dramatic effect on the command and control of forces. The "fog of war" that permeated past conflicts will be greatly reduced by the use of networks to pass information near real-time.[51] No longer will a force go into battle blindly. The sequential decision-making cycle of the hierarchical structure will need to give way to collaborative decision-making at all levels and larger spans of control if we are to take advantage of the information superiority gleaned from digitization. With these changes in command and control come potential pitfalls. Before we can make these changes we need to address how much control we can give to a single leader and at what level and how do we prevent the potential for micro-management at higher levels. The answer to these questions can only be answered through experimentation, in a training environment, and education through military schooling.

[51] Alberts, 74.

Conclusion

While some of the ideas presented in this paper might sound like science fiction, there is no mistaking that the Army is pressing ahead with its automation effort. The Army has invested a tremendous amount of money into the research and development of it 21st century force and does not appear to be effected by the numerous technological roadblocks. From a soldier's perspective I have many concerns. First, is the issue of reliability. The 21st century force is relying heavily on computer technology and various other non-durable technologies. Computers are not the user-friendliest devices nor, for now, are they very rugged. They tend to crash and frequently have other failures. Other technologies that the Army intends to use, such as video cameras, infrared sensors and GPS devices are good for sterile environment use but will require some hardening to stand up to a field environment. This hardening process normally consists of a metal box with packing material that makes the equipment too heavy and cumbersome. With all these advancements, the technology still needs to get smaller, lighter, reliable, and more durable. Computers and networks need to be more mature so that there use will become second nature to its user and self-healing when problems occur. When and if we make the transition to Land Warrior, soldiers will expect the equipment to be nearly flawless and must be as reliable as pulling the trigger of their weapon and knowing it will fire or putting on a protective mask and knowing they can survive the chemical attack. Why? Because their life depends on it. One of the first things you're taught, when entering the Army, is to trust you equipment. The Army teaches you to react by reflex so that you don't have to think. This requires equipment that works 99% of the time as advertised. An additional concern is the tarnishing of soldier skills. As we become more reliant on machines we tend to forget those skills that the machine does for us. If we do not continue to practice those skills manually and the technology fails us we may not only die on the battlefield but our Army could be beaten on it. I think the idea of battlefield digitization is inevitable and necessary and I must applaud the Army leaders for treating this concept as an experiment. This will ensure that before its is released to the Army as a whole it will have been combat tested.

From the perspective of a technologist, I am extremely excited at the possibilities. If we continue on the technological pace of the last fifty years, it is likely that humans will not have to populate the battlefield, machines will. The key to winning a battle has always has been about having good information and using it correctly. The networked systems of the 21st century Army stand to provide us with unparalleled information about enemy forces and our own forces. Instead of going into an unknown situation, now we will know what awaits us down to the last soldier. We will see our enemy and know his intentions, which will allow us to disrupt his decision cycle. The information provided by these sensors will allow us to strike the enemy before he even knows we are there. While network technology is still evolving, we have seen its potential in the Internet. Literally millions of people use it everyday. The promise of wireless, and satellite communications as well as spread spectrum and ATM promise more efficient use of bandwidth, improved security and the ability to communicate anywhere in the world. Devices continue to get smaller and more powerful every year. We can pack more transistors on a smaller wafer than ever before and the promise of Moore's Law has held true since its inception in the 1970s. With the advancements in nanotechnology, it is only a matter of time before we can make devices so small that they will be invisible to the human eye. At that point, size, weight and durability will become mute. While we are improving our technology, we must not overlook the soldier who must use the technology. Thought must be given to establishing training programs which allow the soldier to use the technology provided. The military services cannot assume that a person entering the service will be "technically literate". I look forward to the day when man will not have to sacrifice lives for ideals or politics and the machines of the world can settle the disputes.

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